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ELEVATOR

[EREBĒTA]

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/1[1]

(54) [Title of the Invention]

Elevator

/2[1]

[Scope of Patent Claims]

[Claim 1] An elevator that has a rope fitted with a car on one end and a weight on the other end and a pulley located above the car and suspending the rope, and is characterized by providing a control part meant for the purpose of a controlling operation according to the weight of the car, a first computation part to compute a load weight of the rope with an output from this control part as an input, a second computation part to compute a real load of the rope with an output from this first computation part as an input, a determination part that determines damage by comparing it with a damage database of the rope with an output from this second computation part as an input, and a means generating an alarm according to determination result from this determination part.

[Claim 2] The elevator, as set forth in Claim 1, characterized by having marks at a prescribed spacing provided at the periphery of the rope, a detection part meant to detect the wear

[1]Numbers in the margin indicate pagination in the foreign text.

status of this marks, and the first computation part with an output from these detection part.

[Claim 3] The elevator, as set forth in Claim 1, characterized by the fact that it has two or more layers of an outer film of different colors that are provided at the periphery of the rope, light-emitting diodes irradiating a light on an inner layer that is exposed due to wear of the outer film, and a detector receiving a reflecting light from the inner layer.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to an elevator having a rope for moving a car.

[0002]

[Prior Art]

A rope-type elevator is provided with a drive device comprising a winding machine for a main rope (called as a rope hereafter), a sheave as a pulley mounted to this winding

machine, and a deflector wheel. A car is connected to one side of the rope wrapped on the sheave, and a counterweight is connected to the other side. The car and the counterweight go up and down due to friction between the sheave and the ropes applied with weights of the car and the counterweight.

[0003]

A rope is generally formed by twisting steel wires to form strands and further twisting the strands.

A rope sometimes is formed by twisting strands to form a Schenkel (<4]9Ψ) structure and further twisting it. This steel rope satisfies friction characteristic, wear resistance, fatigue characteristic, and so on necessary for driving an elevator and has high reliability, for instance, it is said to have high reliability, however, it is denied to have a long lifetime because the friction with a sheave is continuously applied, causing degradation.

Accordingly, with the conventional steel rope, rupture of wires is visually confirmed in a status of stopping an elevator, and damage parts of wires of the rope is searched by a crack detection method using magnetism, such as a leakage magnetic flux method or the like.

[0004]

As is described in Unexamined Japanese Patent 2001-19298, a method wherein the number of bending times of a rope is presumed from traveling time data of an elevator in a certain period, and the lifetime of rope is determined by comparing it with a preset determination value is given.

[0005]

Moreover, for instance, Unexamined Japanese Patent 05-162934, Unexamined Japanese Patent 2001-262482, Unexamined Japanese Patent 2001-302135, and so on are given as other examples of the prior art.

[0006]

[Problem to Be Solved by the Invention]

In order to properly determine the deterioration status of a rope, a manager of a rope needs to reliably grasp this abnormality before the rope is not good for use.

[0007]

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In the above Unexamined Japanese Patent 2001-19298, however, when a resin coated rope is used, an optical fiber is disposed in the rope, and the lifetime of rope is determined from a change in quantity of transmission light of the optical fiber accompanied with the number of bending times. If so, the outer coating of the resin coated wire rope has not only a high

number of bending times but also a high frictional coefficient and/or a long slip distance in some cases, and damages such as wear increases, therefore it is difficult to determine the lifetime of the outer coating. The object of the present invention consists in providing an elevator capable of determining a replacement period for a rope with high reliability.

[0008]

[Means for Solving the Problem]

The above object is achieved by providing an elevator having a rope fitted with a car on one end and a weight on the other end and a pulley located above the car and suspending the rope, wherein a control part controlling operation according to the weight of the car, a first computation part computing a load weight of the rope with an output from this control part as an input, a second computation part computing a real load of the rope with an output from this first computation part as an input, a determination part determining damage by comparing it with a damage database of the rope with an output from this second computation part as an input, and a means generating an alarm according to determination result from this determination part.

[0009]

The above object is achieved by having marks at a prescribed spacing provided at the periphery of the rope, and by having a detection part for the purpose of detecting the wear status of these marks, and the first computation part with an output from this detection part as an input.

[0010]

The above object is achieved by having two or more layers of an outer film made up of different colors that are provided at the periphery of the rope, light-emitting diodes irradiating a light on an inner layer exposed due to wear of the outer film, and a detector receiving a reflecting light from the inner layer.

[0011]

[Embodiment of the Invention]

An elevator management company provides its own internal standard of about 5 to 7 years as a replacement frequency of a rope pulling an elevator, however, if no abnormality is found at the time of annual inspection, the elevator is continuously used regardless of the internal standard.

[0012]

The number of running times is markedly different depending upon the type of a building provided with the elevator. For instance, if an office building and a mansion are compared, the

number of running times is much larger in the elevator of the office building, and replacement is probably necessary before an elapse of years prescribed by the internal standard. In the case of a mansion, on the other hand, the wear is less, even though replacement is not needed, the elevator is replaced from the reason of an elapse of prescribed years, and this sometimes is unfavorable in cost.

[0013]

Accordingly, the inventors of the present invention made various studies on an elevator having a monitoring system capable of always monitoring the wear state of a rope and generating an alarm for replacement when the wear of rope is severe even though prescribed years are supposed not to elapse; consequently they gave the following embodiment examples.

[0014]

One embodiment example of the present invention is described by the various figures.

[0015]

Fig. 1 is block diagram for describing a rope lifetime remote monitoring system is one form of this embodiment example.

In Fig. 1, a rope-type elevator is provided with a drive device comprising winding machine **2**, sheave **3** and deflector wheel **4**. A weight of car **6** is applied to one side of main rope **5**

wrapped on sheave **3**. A counterweight **7** is connected to the other side of this rope **5** via sheave **3** to apply a weight. Deflector wheel **4** separates counterweight **7** at a prescribed distance from car **6** to avoid collision of counterweight **7** and car **6**. Rope **5** allows car **6** and counterweight **7** to go up and down due to friction of sheave **3**. Rope **5** is bent on the car **6** side and the

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counterweight **7** side with sheave **3** as boundary during operation of the elevator.

[0016]

Next, a rope lifetime remote monitoring system **1** shown in dotted lines is described by a flowchart. Operation control computer **1a** controls the position, velocity, weight, number of running times, and so on of car **6** based on operation of the elevator and records these data. N computation part **1b** calculates the number of bending times, passing length of sheave **3** and number of passing times of rope **5** with data from operation control computer **1a** as an input. F computation part **1c** calculates the weight onto rope **5** corresponding to the weight of car **6** increased/reduced by the number of passengers. Rope real load computation part **1d** (wrong letter "**c**" in original document, translator) calculates a damage ratio of the ropes with the data from F computation part **1c** as an input. Damage estimation part

1f estimates damages of the ropes with the data of rope real load computation part **1d** and rope damage database **1e** as an input. Rope damage determination part **1g** determines whether replacement for the rope is needed or not with the data from damage estimation part **1f** as an input. If the rope is damaged above a prescribed value, it is informed to a maintenance manager; if it is within the prescribed value, the normal operation is continued.

[0017]

Fig. 2 shows an example of dividing rope positions for specifying bending parts.

In Fig. 2, **8** is marked and fitted into the outer coating of rope **5** in the shape of ring at a prescribed spacing. These marks are judged by colors different from the outer coating. The spacing clarifies parts with heavy wear by positional correspondence of a moving floor of car **6** and a rope position bending at this time. A detection part detecting the wear status of these marked part is provided. The data from this detection part are taken as load weight data of the rope.

[0018]

On the other hand, a weight added to car **6** by passengers can be obtained by a measurer (non-illustrated) for detecting the load weight given by passengers from flexure of a hard

rubber provided in the lower part of car **6** as operation control data, therefore the weight added to rope **5** in rope load weight computation part **1c** can be computed by totaling this weight and the weight of car **6** measured beforehand.

When rope **5** is fixed to the inner wall of a hoistway, a tension detector may also be installed on a simple rod (non-illustrated) for binding rope **5** to detect a tension added to rope **5**.

An estimation is made by rope real load computation part **1d** from these results.

[0019]

Damage factors of the rope can be classified into four parts.

(1) Fatigue caused by bending and extension when passing through sheave **3**.

(2) Wear due to relative slip of wires on each other.

(3) Wear of wires of outer layer of rope due to contact with the wall surface of groove of sheave **3**.

(4) Corrosion due to contact with atmosphere.

Particularly, in case of rope **5** for elevator used as a running rigging, it was known that the wear caused by relative slip of wires constructing the rope **5** and a coating resin increased due to bending accompanied by passage of rope **5**

through sheave and the rupture strength of the whole rope reduced. Thus, deterioration of rope **5** can be expressed as a reduction of the rupture strength.

The reduction of rupture strength is also caused by decreasing the cross-sectional area of wires due to corrosion of wires.

[0020]

Fig. 3 is a relationship between the number of sheave passing times of a rope and the wear ratio calculated from observation of the cross-section of rope wearing when a 8-shaped bending test for testing rope **5** by loading a tension of 6.0 kN on a resin coated wire rope and bending it in the shape of 8 with a 200 mm-diameter sheave.

As shown in Fig. 3, the wear of wires is increased with the growing number of sheave passing times, i.e., the number of bending times. The wires are applied with zinc plating or brass plating, however, corrosion is generated by peeling of the plating layer due to wearing and becomes a reason for the wearing.

[0021]

Thus, if the wear of wires increases due to the relative slip of wires on each other with an increase of the number of

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sheave passing times of rope **5**, the cross-sectional area of the wires decreases, thus the rupture strength of the whole rope reduces.

The 8-shaped bending test is carried out by changing the tension based on this data, and the lifetime determination considering the number of passengers, i.e., a difference of weight loaded on a rope, can be made by preparing a rope damage database **1e** shown in a flowchart of Fig. 1 with the result of the test as a database. Here, the rope damage value is determined by damage estimation part **1f** of Fig. 1 at positions of the rope from the number of sheave passing times and the tension loaded on rope **5**.

[0022]

Fig. 4 shows a relationship between the rope damage value and the residual rupture strength.

As shown in Fig. 1, it is known that the residual rupture strength reduces if the rope damage value increases due to bending of rope **5**.

As shown in the flowchart of Fig. 1, when it is determined that the value is a prescribed value requiring rope replacement, the rope replacement is informed a manager by an exclusive line, a telephone line or an internet. If the value exceeds a prescribed value, the normal operation is carried out.

[0023]

Thus, the lifetime of rope **5** can be determined beforehand by grasping the deterioration progress status of rope **5** from the rope real load computation and rope damage database **1e** based on operation control data of an elevator.

Even in a failure by any chance, a reason can be specified in the early stage, and a quick restoration becomes possible.

[0024]

Fig. 5 is a cross-sectional view of a rope provided with another embodiment example.

In Fig. 5, outer coating **9** is taken as a transparent resin, such as polyurethane, polyamide, polyethylene, and damages inside rope **5** can be visually checked. Resin coated rope **5** is formed by twisting steel wires **10** to form strands **11** and further twisting them. At this time, inner coating **12** such as polyurethane, polyamide, polyethylene, or the like may also be applied to strands **11**. A resin is filled into gaps of wires or strands **11** at the time of coating the resin. Fig. 5 shows outside diameter position **13** of twisted wires and outside diameter position **14** of strands **11**.

[0025]

In the mutual wear of wires due to bending accompanied by passage of rope **5** through sheave, the slip distance is small,

and the same places are repeatedly rubbed to become flatting wear. Wearing powder generated at this time becomes an oxidized wearing powder and is dark brown in many cases.

[0026]

Accordingly, if outer coating **9** is transparent and the dark brown wearing powder inside it can be visually confirmed, the reliability for diagnosis of rope deterioration rises. Corrosions of wires due to moisture penetrated from air through outer coating **9** can also be visually confirmed.

At this time, wire themselves can also be visually checked by using a transparent resin, such as polyurethane, polyamide, poyethylene for inner coating **12**, therefore generation of the wearing powder can be confirmed.

[0027]

Fig. 6 is a cross-sectional view of a rope provided with another embodiment example.

In Fig. 6, secondary outer coating **15** that is a resin having a color different from the outer coating is coated on the inner side of outer coating **9** to take a multilayer structure.

When the outer coating is worn, secondary outer coating **15** having a different color occurs by taking a multilayer

structure, therefore the wear of the outer coating can be easily confirmed by visualization.

[0028]

Fig. 7 is a schematic diagram of an outer coating wear monitoring system for a resin-coated wire rope providing still further another example.

In Fig. 7, when outer coating **9** is worn and a resin of a

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different color is exposed, a light irradiated from light-emitting diode **16** is irradiated on the exposed resin, a reflecting light from the exposed resin is received by detector **17** to determined the extent of wear. These light-emitting diode **16** and detector **17** are connected to control computer **1a** shown in the flow diagram of Fig. 1.

Light-emitting diode **16** and detector **17** of its reflecting light may also be disposed at plural positions to cause the wear of outer coating **9** on faces in contact with sheave **3** and deflector wheel **4**, and so on and inspect the contact faces, respectively. If light-emitting diode **16** and detector **17** of its reflecting light are disposed in the vicinity of sheave **3** and deflector wheel **4**, damages of outer coating **9** can be found in an early stage.

[0029]

If light-emitting diode **16** and detector **17** of its reflecting light are disposed in the winding machine, vibration is less and the accuracy of detection is better than in a case of disposing them on the car.

When a resin of different color is detected, rope replacement is informed to a manager by an exclusive line or telephone line or an internet. The friction with sheave **3**, i.e., changes of a traction that is the friction between outer coating **9** of rope **5** and sheave **3** can be reduced by making a resin coated on the inner side of the outer coating into a material same as outer coating **9**, such as polyurethane, polyamide, polyethylene, and so on, even if outer coating **9** is shaved due to the wear.

[0030]

The even longer lifetime raises the reliability of an elevator simultaneously with the lifetime diagnosis of resin coated wire rope **5**.

[0031]

Fig. 8 is a sectional view of a rope showing one embodiment example for raising the wear resistance of a rope.

In Fig. 8, steel gauzes **18** are put into outer coating **9**. In addition to the steel gauze, a fiber such as polyamide, polyethylene, or the like may also be inserted by making it into gauzes.

The wear resistance of outer coating **9** is improved and the wear of outer coating **9** due to the contact with sheave **3** is reduced by inserting these gauzes. Even if the degree of adhesion of outer coating **9** and strands **11** is low and only the outer coating is stretched, the rupture and deformation of outer coating **9** can be prevented and a long lifetime of the resin coated wire rope can be achieved.

[0032]

Fig. 9 is a sectional view of a rope showing still another embodiment example for raising the wear resistance of the rope.

In Fig. 9, inner coating **12** is applied only to center strands, and resin wall **19** is disposed at mutual contact points of wires **10**.

[0033]

A ratio (D/d) of rope diameter d to sheave diameter D of above 40 is ensured for use with the purpose of reducing effects due to repeated bending at the time of passing the sheave before. Accordingly, the ratio (D/d) can be kept to a high value even if the sheave diameter D is decreased by decreasing the rope diameter d. Thus, the rope diameter can be decreased and the fatigue damage of wires can be reduced by decreasing the occupied area of inner coating **12** at the rope cross-section.

[0034]

Fig. 10 is a sectional view of a rope showing still another embodiment example for raising the wear resistance of the rope.

In Fig. 10, strands **11** applied with inner coating **12** are alternately arranged, and the diameter of wires **10** of strands **11** applied without the inner coating is larger than that of other strands. In embodiment examples shown in Fig. 6, Fig. 8, strands **11** are applied with the inner coating to prevent the wear caused by direct contact of wires in inner coating **12**, however, it is effective that wires **10** are thickened to improve the strength of rope in this embodiment example.

Accordingly, strands **11** applied with inner coating **12** are alternately arranged and the wire diameter of strands **11** applied with inner coating **12** is increased, thereby the strength of rope is improved. The rupture of wires due to wear is hard to occur and a long lifetime of the rope becomes possible by thickening the wire diameter.

[0035]

The inner coating and the outer coating shown in embodiment examples of Fig. 8 ~ Fig. 10 so far are directly coated on steel wires, thus the adhesive force is not enough. However, if a

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rubber such as natural rubber, styrene-butadiene rubber or the like is used and coated on a coating material by applying brass

plating, zinc plating, or the like to the wires and then vulcanization, the adhesive force can be increased.

When brass is used for plating, a sulfur atom sulfurizes copper to prepare CuS by using proper vulcanization conditions, on the other hand, the adhesive force is increased by chemical adsorption of a rubber molecule on copper with the sulfur atom. Slip between the wires and the coatings can be reduced by increasing the adhesive force of the coating material, thus the wear between the wires and the coatings can be reduced.

A low adhering force between the wires and the coatings is one reason for mold collapse (6≅8=⊥Z) of a rope coming from collapse of twisting of the wires and strands, and the wires cannot be easily separated by increasing the adhesive force between the wires and the coatings to prevent the mold collapse of rope.

[0036]

[Effects of the Invention]

The present invention enables to provide an elevator capable of determining a replacement period for a rope with high reliability.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a schematic diagram of a rope lifetime remote monitoring system that is one example of an embodiment of the present invention and a flow diagram of this system.

[Fig. 2] Fig. 2 is a schematic diagram of a rope provided with one embodiment example of the present invention.

[Fig. 3] Fig. 3 is a graph showing the wear ratio of a rope as a database of the rope lifetime remote monitoring system that is one embodiment example of the present invention.

[Fig. 4] Fig. 4 is a graph showing the wear ratio of a rope as a database of the rope lifetime remote monitoring system that is one embodiment example of the present invention.

[Fig. 5] Fig. 5 is a sectional view of a rope provided with another embodiment example.

[Fig. 6] Fig. 6 is a sectional view of a rope provided with another embodiment example.

[Fig. 7] Fig. 7 is a schematic view of a rope provided with another embodiment example.

[Fig. 8] Fig. 8 is a sectional view of a rope provided with another embodiment example.

[Fig. 9] Fig. 9 is a sectional view of a rope provided with another embodiment example.

[Fig. 10] Fig. 10 is a schematic view of a rope provided with another embodiment example.

[Explanation of References]

1 rope lifetime remote monitoring system

2 winding machine

3 sheave

4 deflector wheel

5 rope

6 car

7 counterweight

8 divided resin

9 outer coating

10 wire

11 strand

12 inner coating

13 wire diameter line

14 strand diameter line

15 secondary outer coating

16 light-emitting diode

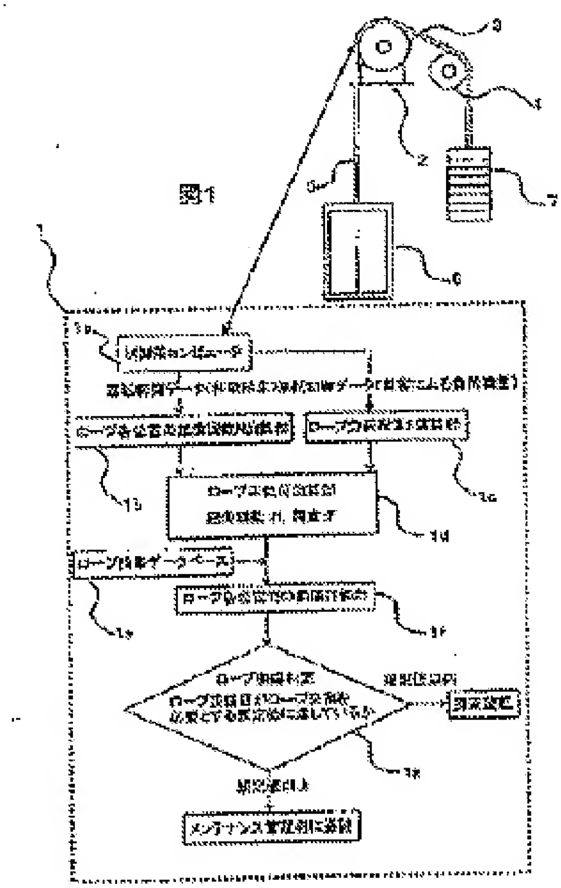
17 detector

18 steel gauze

19 resin wall

/8

[Fig. 1]



1a control computer

1b Bending times N computation part for each position of rope

1c rope load weight computation part

1d rope real load computation part (bending times: N, weight: F)

1e rope damage database

1f damage estimation part for each position of rope

1g Rope damage determination part

(between **1a** and **1b**) operation control data moving floor)

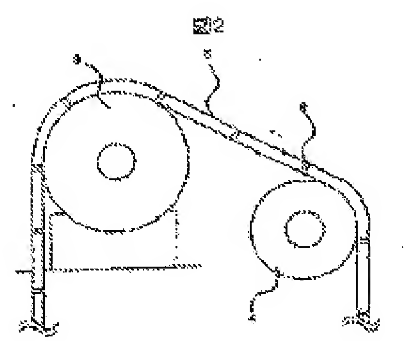
(between **1a** and **1c**) operation control data (load weight due to ? (unclear))

(after **1g**) above prescribed value → normal operation

(under **1g**) above prescribed value (inform to maintenance manager)

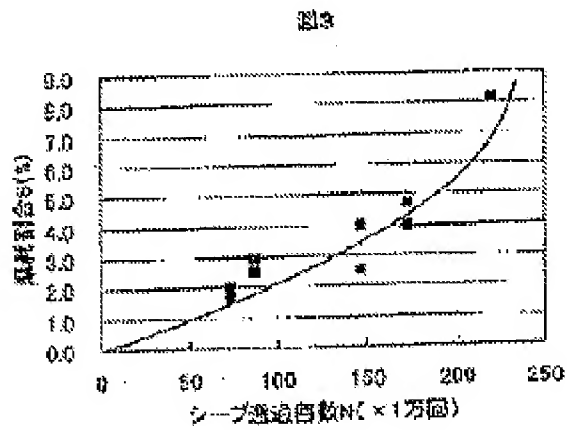
[Fig. 2]

【図2】



[Fig. 3]

【図３】

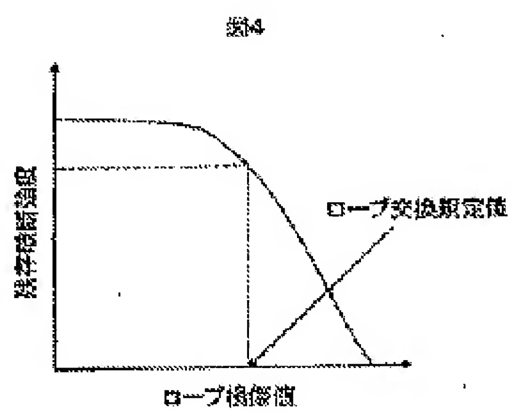


Y-axis= Wear ratio 8(%)

X-axis= Number of sheave passing times (×10,000 times)

[Fig. 4]

【図４】

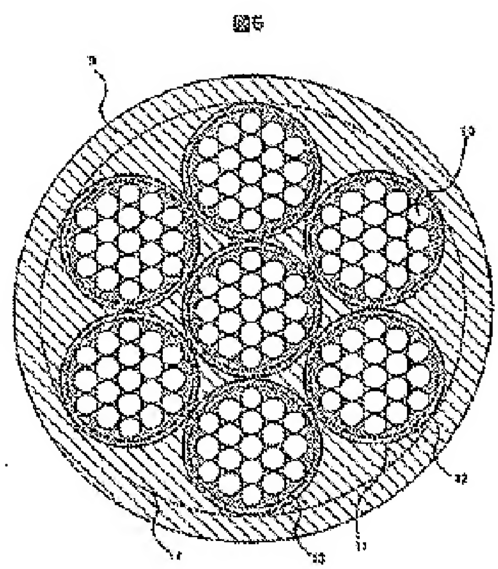


Y-axis= Residual rupture strength

Prescribed value for rope replacement

X-axis= Rope damage value

[Fig. 5]



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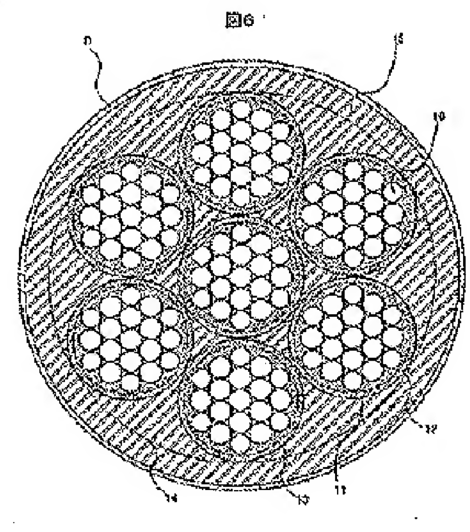
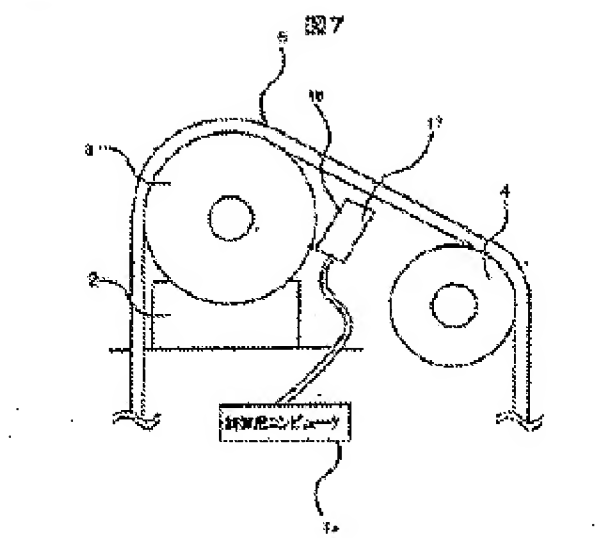
[Fig. 6]



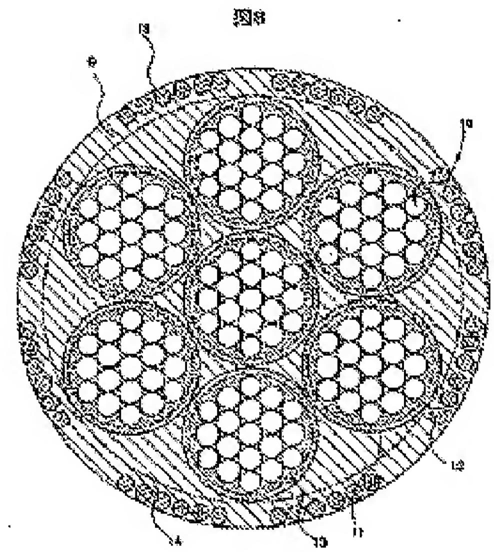
[Fig. 7]

【図７】

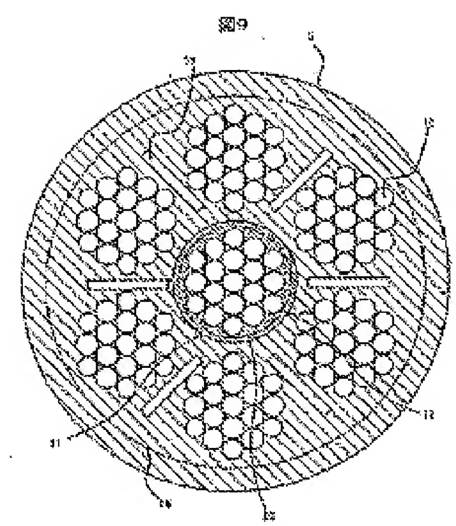


Control computer

[Fig. 8]



[Fig. 9]



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[Fig. 10]